CORRELATION OF RESONANCE CHARGE EXCHANGE CROSS-SECTION DATA IN THE LOW-ENERGY RANGE

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During the course of a literature survey concerning resonance charge exchange, an unusual degree of agreement was noted between an extrapolation of the data reported by Kushnir, Palyukh, and Sena[1] and the data reported by Ziegler.[2] The data of Kushnir et al. are for ion-atom relative energies from 10 to 1000 ev, while the data of Ziegler are for a relative energy of about 1 ev.

Extrapolation of the data of Kushnir et al. was made in accordance with Holstein's theory,[3] which is a combination of time-dependent perturbation methods and classical orbit theory. The results of this theory may be discussed in terms of a critical impact parameter b_c. For impact parameters less than b_c, the theory says the probability of charge exchange P is a rapidly oscillating function of b with extremes at 0 and 1 and an average value of $\frac{1}{2}$. For $b > b_c$, P rapidly drops from $\frac{1}{2}$ to zero with increasing b. Holstein gives the expression for P as a function of b and relative energy ϵ. Setting P equal to $\frac{1}{2}$, he gets an equation for all the b's where P passes through $\frac{1}{2}$. If attention is restricted to the largest b, which is a solution to this expression, we have b_c as a function of energy. If b_c is used to compute a cross section ($\sigma = \pi b_c^2$), Holstein's theory gives

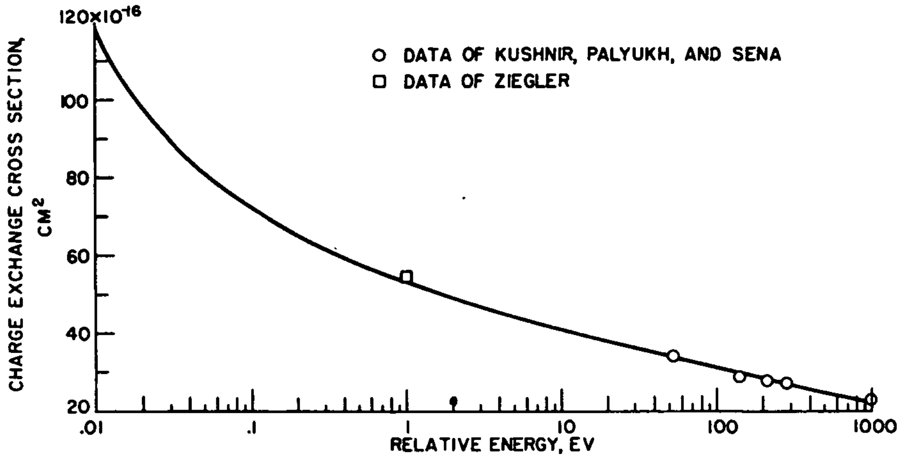

FIG. 1. Charge exchange cross section for Ar^+ in Ar. Curve is Eq. (1) fitted to data of Kushnir et al.

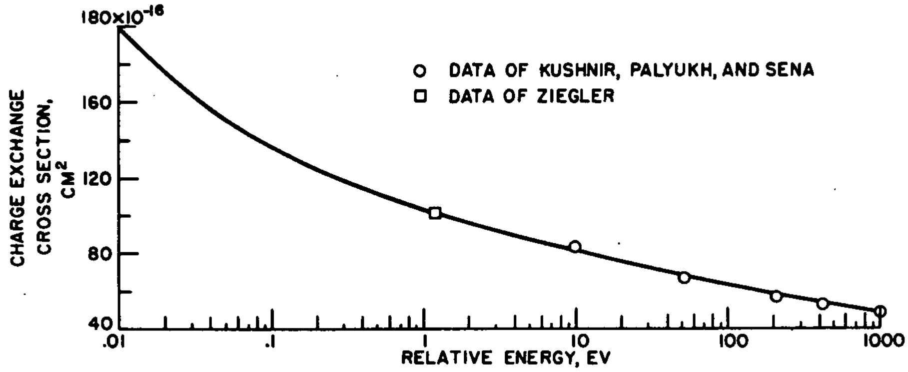

FIG. 2. Charge exchange cross section for Xe^+ in Xe. Curve is Eq. (1) fitted to data of Kushnir et al.

a charge exchange cross-section energy relationship of the form,

$$\epsilon = K_1 \sigma^{1/2} \exp(-K_2 \sigma^{1/2}),$$

where K_1 and K_2 are functions of the interaction potential. Note that, for a given ϵ, σ is double valued. The lower σ value had no meaning as a cross section. It corresponds to one of the b's less than b_c where the oscillating P passes through $\frac{1}{2}$. A curve of the form of the above equation was fitted to the data of Kushnir et al. These curves (corrected for polarization[3]) are shown in Figs. 1 and 2 for Ar and Xe, respectively. The data of Ziegler are also shown in these figures.

The mobilities of Ar and Xe were computed according to Holstein[3] using the extrapolated cross-section curves of Figs. 1 and 2. The computed values of mobility are compared in Table I with experimental values reported by Biondi and Chanin.[4]

The agreement of the two sets of cross-section data with each other and with mobility data is unusually good when one considers the wide range of energy included in the correlation.

Table I. Mobility at 300°K.

	Mobility (cm²/volt-sec)	
	Biondi and Chanin[a] (experimental)	Extrapolation of Kushnir, Palyukh, and Sena data[b]
Ar	1.6	1.50
Xe	0.595	0.453

[a]See reference 4.
[b]See reference 1.

[1]R. M. Kushnir, B. M. Palyukh, and L. A. Sena, Izvest. Akad. Nauk S.S.S.R. 23, 1007 (1959) [translation: Bull. Acad. Sci. U.S.S.R., Phys. Ser. 23, 995 (1959)].

[2]B. Ziegler, Z. Physik 136, 108 (1953).

[3]T. Holstein, J. Phys. Chem. 56, 832 (1952).

[4]M. A. Biondi and L. M. Chanin, Phys. Rev. 94, 910 (1954).